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Contributions to the Geology of Southwestern Iowa

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CONTRIBUTIONS TO THE GEOLOGY OF SOUTHWESTERN IOWA.

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During the past summer (1917) Geologic work has been engaged in as opportunity offered in Montgomery, Page, and Fremont counties. The fault line north of Thurman has been definitely located, on East Nishnabotna river much information of importance has been obtained by observation and study of the different outcrops from Essex north to Stennett, and on Nodaway river at Clarinda, Shambaugh, and Braddyville outcrops were visited and fossil collections made.

The Braddyville and Shambaugh outcrops, at the present time, are greatly obscured, and little of value can be secured at these places. Search of the mine dumps at New Market and Clarinda was made to secure additional material for paleontological study of the shales in immediate contact with the Nodaway coal. The writer is convinced the complex geology of southwestern Iowa is not sufficiently known or recognized at the present time. Instead of having great simplicity in its structure and stratigraphy, there are numerous complications caused by erratic dips and by the great Jones Point deformation, and the extent and influence on the local geology of the Brownville syncline that reaches into Iowa to the southeast corner of Cass county has not been appreciated. To all this complexity is added the enormous difficulty caused by the Pennsylvanian being deeply buried, except in a few scattered localities, by Pleistocene deposits which in the divides between the streams in places reach a depth of 200 feet. In the valley of East Nishnabotna river as far south as Coburg the Pennsylvanian is overlain unconformably by Cretaceous sandstones and shales upwards of one hundred feet in thickness. Exposures of strata are few in number and distant from each other, which necessitates wide correlations with increased chances of error. The finality in the interpretation of the geology of southwestern Iowa has by no means been reached as yet. In the future many attempts will be required to accurately fix the stratigraphic relations of the puzzling succession of the limestones and shales found in the Missouri stage of Iowa. Without any desire to excite controversies as to what has been found in other states it may be expedient for the writer to state the con-

clusions he has arrived at after at least a diligent study of the geology of southwestern Iowa.

In the past correlations of strata have almost exclusively been founded on the different limestones, to the general neglect of the coal seams and black shales; these latter are much more constant and certain horizon markers than the former. Although the limestones of the Missouri stage are fairly constant they are nevertheless given to coalescing with each other and feathering out; the gradual introduction of additional layers to a ledge may change its appearance within a few miles and cause it to be erroneously correlated. Also the splitting of a thick limestone by a thin shale parting in one locality and the increase in the thickness of the shale in another not far distant may divide the ledge by many feet, and so give the appearance of two separate ledges of limestone which seem to belong in an altogether different place in the general section. The paleontological method does not much help the situation as there is no abrupt change in the fauna throughout the whole succession of strata. The continued studies of the writer have so extended the range of the brachiopod element as to show that different species range through the whole section. The pelecypods are of more value in correlations, especially as the Tarkio is an important Myalina horizon, and in the shales immediately above the Tarkio there are many small pelecypods of difficult determination. Also the main limestone at Stennett has an exceedingly abundant echinoid fauna. The corals and gastropods are found sporadically through the whole section. It is thought the bryozoa may be of the utmost value in correlations and that in the future all precise paleontological correlation must be done by the bryozoa. However, their study is most difficult and repellant to the student and practically nothing has been done in that line in Iowa. Many years ago the late Doctor Calvin in conversation with the writer stated that the fauna of the Missouri stage was found in colonies, and the different species in each colony were very similar. The correlation of the strata in southwestern Iowa must mostly be done by the stratigraphical method although paleontology affords a useful check. In a geological field where outcrops will average twenty miles apart correlations should be made with the greatest caution. Especially would the writer deprecate attempts to correlate the strata in Iowa with those of localities in other states several hundred miles distant.

In the past the writer has not favored the giving of taxonomic value of formations to limestone caprocks and shale partings that will not average a yard in thickness. However Condra and Bengtson in their recent report on the "The Pennsylvanian Formations of Southeastern Nebraska" have for the different limestones applied the term ledges, and have named and numbered twenty-six ledges found in the Pennsylvanian of their state. Although this method introduces a multiplicity of names it serves a most useful purpose and avoids much circumlocution in description. As certain of these ledges can readily be recognized in Iowa the Nebraska names and numbers will be adopted by the writer.

In the Page county report Volume 11, Iowa Geological Survey, Doctor Calvin described and named the Tarkio formation, and gave as a type section one three miles northeast of Norwich. In this section two ledges of limestone are shown divided by twelve feet of shale. In the Nebraska report the Tarkio is only given the taxonomic rank of a ledge, and the name is applied to the upper ledge, while the lower ledge is named the Preston ledge. This is an injustice to the late Doctor Calvin, as this formation was clearly delimited above and below and a type section given. However, to avoid complications in descriptions the Nebraska method is reluctantly accepted. In Volume 19, Iowa Geological Survey, the writer extended the City Bluffs beds of Broadhead up to the Tarkio as at that time there seemed to be no constant horizon to divide upon. The records of the different coal mining shafts included only one hundred feet of shale underneath the Pleistocene, directly above the cap rock of the Nodaway coal, and above this thick shale no outcrops were known in Iowa showing the rest of this interval. Also the records of core drilling are not in close agreement with one another, as to the stratigraphy found above this shale. It is now known that the one hundred feet immediately underlying the Tarkio contains three limestone ledges; including the Tarkio, the Nebraska geologists have named them commencing with the highest Tarkio, Preston, Fargo, and Burlingame. The Rulo has not been found in outcrop east of Missouri river. Condra and Bengtson have divided the strata in the interval between the Nodaway coal and the Tarkio into two formations, the upper one hundred feet being named the Nemaha formation, with its lower limit at the Rulo and its upper at the Tarkio. They retain the name City

Bluffs for the lower one hundred and twenty-five feet reaching from the Rulo to the Nodaway coal, thus returning to the original use of the name as given by Broadhead. This is more correct than the former use of the name and is acceptable to the writer.

However, the Nemaha of Condra and Bengtson, and the McKissicks Grove of Smith should have no standing in geology as both of these formations are included in the Atchison county Group of Broadhead, who in 1872 gave this name to a series of strata in Atchison county, Missouri, exposed in the bluffs along Missouri river. At the base of the exposure was a limestone, number 28 of his section, now known to be the Burlingame, the third limestone ledge below the Tarkio, and the section extended upward to a red shale, his number 3, the latest of the Pennsylvanian found east of Missouri river. Broadhead's Atchison county Group was accurately defined according to modern standards. This section has recently been reviewed in the field and found to be correct in detail. No geologist of the present time having any regard for the permanency of his own work can afford to ignore the accurate work of his predecessors. Keyes' Atchison formation has no application here as he places the lower limit of his Atchison at the Forbes at least one hundred and fifty feet lower than the base of the Atchison county Group.

During the past summer several days were spent in tracing the different outcrops and strata exposed in the base of the Missouri river bluffs, from two miles south of Thurman along the bluff road north to Wabonsie creek, a distance of nearly seven miles. The utmost care was exercised to secure accurate results in this work as the object was to definitely locate the fault line north of Thurman and obtain a solution of one of the greatest problems in Iowa geology. Some of the most intricate geologic structure in the state is present in the vicinity of Lake Wabonsie and requires additional study. The stratified rocks in this part of Iowa are so obscured by heavy deposits of drift, and in the vicinity of Missouri river by loess, that the effect on the local geology caused by the Jones Point deformation, the interpretation of which is fraught with difficulty, is liable to be misconstrued. The writer has not spared time and effort to give a correct solution to some of these problems but much remains for future investigation, and his present interpretations may be greatly modified.

On the Baylor and Mann farms two miles south of Thurman, on the bluff road, are found outcrops of a sandstone separated from an overlying limestone by a shale two feet thick. Udden in the Mills and Fremont counties report, Volume 13, Iowa Geological Survey, gives a composite section of these outcrops, and as his lithogical descriptions are unusually perfect his section will be given verbatim.

XV. SECTION IN THE BLUFFS TWO MILES SOUTH OF THURMAN.

	Feet
6. Bluish gray sandstone of fine texture cemented by a crystalline calcareous matrix	½
5. Gray shale, not calcareous, evidently in part originally a black shale	10
4. A dark gray blotched limestone cut by straight and vertical joints into large blocks and containing numerous spheroidal lumps about one-fourth inch in diameter. In section is seen to be composed of an agglomeration of indurated lumps of calcareous mud, of all sizes up to one-half inch in diameter, and in varying color due to weathering. The larger of these are themselves occasionally composed of agglomerations of smaller nodules. Some show shrinkage cracks and fissuring. In this mass are a few shell fragments, joints of crinoid stems and quartz grains	3
3. Soft bluish gray shale, partially concealed	2
2. Grayish blue sandstone of fine texture and indurated by a crystalline calcareous matrix, in straight lines below, ripple marked above	3
1. Shale, not well exposed	1

Lower strata found in a coal prospect shaft near one of the outcrops continue the section to the Nyman coal.

RECORD OF BAYLORS SHAFT SOUTH OF THURMAN.

	Feet	Inches
6. Blue limestone	3	
5. Sandstone	5	
4. Shale	20	
3. Limestone		6
2. Coal, Nyman	1	2
1. Shale and sandstone		
Total	29	8

This coal has also been prospected on the Mann and McCartney farms farther north toward Thurman and found to have a thickness of six inches to one foot. In the distance from these outcrops to Thurman the same strata are found in numerous outcrops along the bluff road. From Plum creek no outcrops are to be seen until the north line of the village of Thurman is reached where the same strata are again exposed in outcrop. For a distance of one-half mile north of this locality the sandstone ledge

is seen outcropping at a number of places in the bank adjacent the wagon road with a few exposures of the limestone ledge above it. In this distance one of the rare exposures in the Missouri river bluffs of the Aftonian gravel bed was noted in the ditch along the roadside. Besides the usual diabase and quartzitic gravel there were several bowlders of Sioux quartzite up to six inches in diameter, and one of gray granite at least one foot in its greatest dimension. The wagon road leaves the bluffs and turns west and then north on the bottom lands for three-fourths of a mile before it again reaches the bluffs. In this distance the bluffs were carefully searched for outcrops but none were found.

In the bluff at the residence of Chas. Baldwin at an elevation of about twenty-five feet above the wagon road the same strata traced for four miles from the Baylor farm are again found immediately south of the fault line. Udden's Section XIII was evidently taken at this place when the quarry was in operation. As the strata were better exposed at that time than at present his section will be given in full with his lithogical descriptions.

XIII. SECTION OF THE UPPER PART OF THE EXPOSURE IN BLUFF NEAR THE NORTHWEST CORNER OF SEC. 26, SCOTT TOWNSHIP, FREMONT COUNTY.

	FEET
4. A dark bluish limestone of fine texture along some layers and along other seams almost wholly made up of very small and thin shell fragments, lying flat, barely visible under a good hand lens; thin and wavy plates of cone in cone and fibrous calcite occur in this ledge	2
3. Shaly silt	1
2. Dark gray, in places brownish, limestone, with some fossils. A ground specimen is seen to consist of thin pieces of shells, 1 to 3 millimeters across, lying flat in a sparse matrix holding a few small quartz grains	¾
1. An arenaceous and calcareous rock of fine texture and of bluish color, consisting of a siliceous, well assorted silt or sand imbedded in calcareous material. It contains frequent specimens of a Cythere, also a Fenestella, other bryozoa, and fragments of brachiopod shells	2½

Both the limestone and sandstone weather into irregular slabs with a rough granular surface, a good example of which is shown in figure 41 of Volume 17, Iowa Geological Survey, giving a view of the retaining wall in front of Chas. Baldwin's residence. This ledge of limestone and sandstone was not named in Condra and Bengtson's Nebraska report. While reluctant to add to an overburdened terminology the writer would suggest the name Nebraska City ledge for this double ledge. The type section is the

upper strata in the brick yard shale pit one-fourth mile south of the Missouri river bridge at Nebraska City, Nebraska. This ledge is not a constant horizon; in passing south it grades into sandstone and can not be recognized a few miles south of the state line in the state of Missouri. In recent years, Wabonsie creek has been diverted into Wabonsie Lake. At the present time the lake is silted up, no standing water is visible and the old lake bed is grown up with marsh grass. At one time the

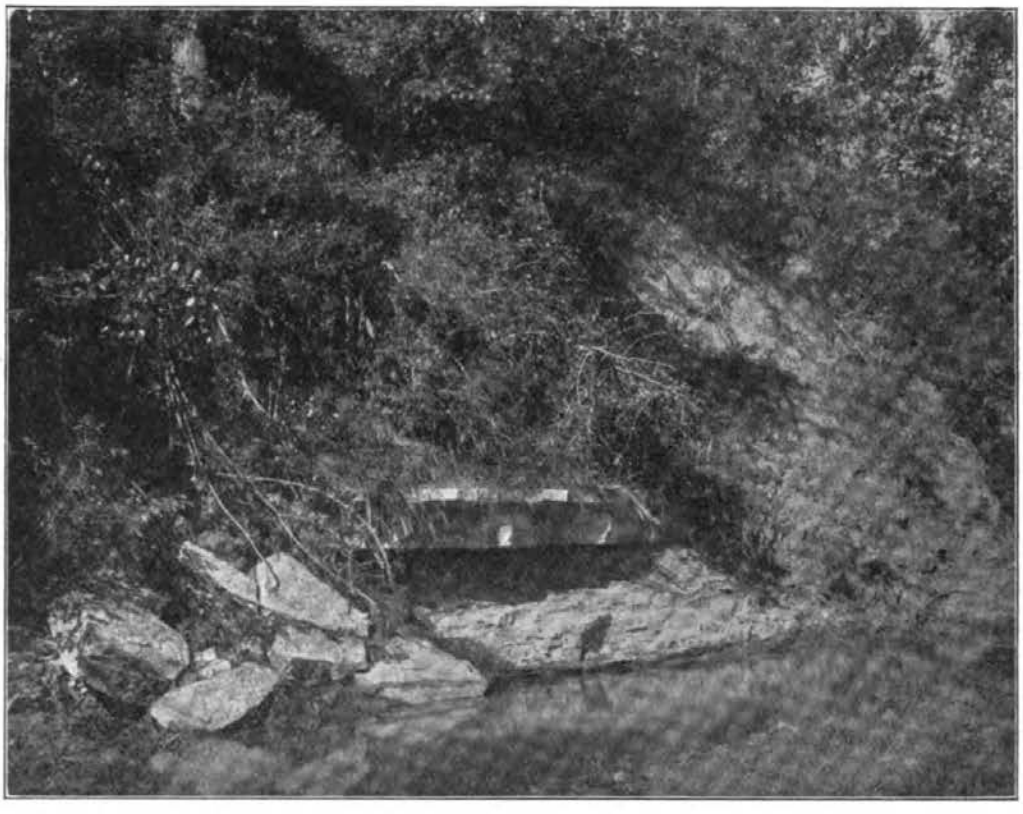

Fig. 169a.—Exposure of the "blue ledge" and associated strata southeast of Essex. (Calvin.)

main channel of Missouri river evidently was at the foot of the rock ledges in the bluffs east of the lake. At present a road grade twelve or fifteen feet in height above the marsh has been constructed at the foot of the bluffs, concealing strata seen by White and described in his "Section at Wilsons," Volume 1, Iowa Geological Survey, 1870. For a distance of nearly one-half mile the lake is bordered by a ledge of light gray, irregularly bedded, shattered limestone, twelve to fifteen feet thick. In one place the base of the limestone was seen resting on a black shale. South

of the Wilson residence there are numerous outcrops of the thick limestone ledge with higher strata resting upon it. One-half mile south of the Wilson house on Murder hill, named in allusion to an occurrence that took place in a house the ruins of which are at the foot of the bluff, is exposed fifteen feet of the Forbes limestone overlain by a complete section of the Braddyville formation, the only one known in the state. This outcrop includes the Meadow, Union, Louisville, and South Bend ledges of the Nebraska geologists.

The upper ledge, South Bend, is the bottom rock of the Nodaway coal. Across a ravine and less than two hundred yards distant is the old quarry in the bluff at the rear of Chas. Baldwin's residence. The bottom of this ravine is on the fault line about fifty yards north of the Baldwin house. It was not possible to run a level between these two points by reason of trees and thick undergrowth. However, the ledge at Baldwin's has approximately the same elevation as the Meadow ledge in Murder hill. The downthrow of the fault to the south includes the Braddyville, forty feet, City Bluffs, one hundred and twenty-five feet, Nemaha, one hundred feet, McKissicks grove, fifty feet, the total amount of displacement being about three hundred and twenty-five feet.

Keyes has named this deformation the Red Oak fault; however Condra and Bengtson's name Jones Point deformation has priority of one year and is moreover a more appropriate name as it is not in all places if indeed it is in a majority of cases a true fault.

All known outcrops on East Nishnabotna river from Essex north to Stennett have been visited, the purpose being correlation of the different exposures and the study of the geologic structure along this stream. From two miles southeast of Essex on Rocky Branch no outcrop of Pennsylvanian rocks is known in the valley of this river until Mill creek south of Riverton is reached. In the Page county report, Volume 11, Iowa Geological Survey, Doctor Calvin in Plate No. 34 gave a view of the outcrop on Rocky Branch as then exposed. Subsequent quarrying operations and erosion of the creek bed have uncovered a still lower ledge of limestone. The section at present is as follows:

		Feet	Inches
9.	Limestone, light gray, weathered yellow		8
8.	Shale, weathered		6
7.	Limestone, blue, weathered yellow		16
6.	Shale, yellow	2	
5.	Shale, blue	7	
4.	Limestone, gray, impure and shaly, in three layers	1	
3.	Shale, weathered	1	
2.	Limestone, bluish gray, one layer cut by vertical joints into large rhombohedral blocks	2	
1.	Limestone, blue, weathered brown, broken into small blocks	1	
	Total	16	6

If the Fusulina layer of the Tarkio is present here it is now concealed by slumping. Doctor Calvin seems to have found it exposed. Numbers 1, 2, 3, 4 represent the Preston and 7, 8, 9 the Tarkio. In a part of the outcrop there is exposed seven feet of Nebraskan drift, crumbly black clay, diagonally jointed, containing pockets of sand and small pebbles of white chert. Eighty rods north of the creek bridge, along the roadside, is seen the Kansan drift, very arenaceous, containing diabase and quartzite gravel and bowlders of Sioux quartzite. Several fragments of friable Cretaceous sandstone were found which could have not been transported in a drift sheet from ledges far distant.

At Coburg in the bluff east of the village there is an excellent exposure of Cretaceous sandstone. It was examined by Lonsdale twenty years ago and is still in good condition.

SECTION IN BLUFF EAST OF COBURG.

		Feet
3.	Shale, light gray, in wagon road cut, south of pit	11
2.	Conglomerate, quartz pebbles, arenaceous limonite matrix, dark brown	8
1.	Sandstone, yellow, cross bedded, friable, with streaks of gravel	24
	Total	43

In the deep road cut about one hundred yards south of the sandstone pit the ferruginous conglomerate is overlain by eleven feet of light gray, poorly bedded shale giving a thickness of forty-three feet of Cretaceous strata in this bluff. Eighty rods south of the wagon road a quarry was opened many years ago which now is much obscured. Immediately under a light covering of drift five or six feet of the Cretaceous conglomerate is seen in place. The quarry was opened in Carboniferous limestone underneath the conglomerate. No undisturbed layers of

limestone in place can be seen. However, among loose blocks and debris it was found that the layers quarried were eight inches of light gray iron stained limestone, and fourteen inches of bluish gray limestone in one layer. A few fossils were found sufficient with the lithogical character of the limestone to justify a correlation with the Tarkio.

At the old Keystone mill site near Red Oak on the Nebraska City branch of the Chicago, Burlington & Quincy railway, in the first bluff south of the main line, an excavation shows Cretaceous sandstone, yellow, friable, massive, cross bedded, with concretions of limonite. The thickness exposed is twelve feet, eight feet of which is above the level of the railroad track. At the time of the visit of Doctor Calvin and the writer eighteen years ago about one hundred yards south of this sandstone pit an outcrop showed above the railroad track ten feet of Cretaceous shale, poorly bedded, arenaceous, with limonite concretions, gradually passing upwards into fifteen feet of light gray shale, free from concretions, jointed, and well bedded; below the railroad track was nine or ten feet of contorted friable sandstone resting unconformably on eighteen inches of light gray Carboniferous limestone in one layer. Doctor Calvin at that time collected specimens of Angiosperm leaves in this sandstone. This is probably the same locality from which Meek collected fifty years ago. A short distance still farther south, where the river at high water washes the railroad embankment, is the place where White obtained his section showing Cretaceous shale extending down to the limestone ledge at water level in the river, with absence of all sandstone.

SECTION NEAR RED OAK, IOWA GEOLOGICAL SURVEY, VOL. 1, 1870.

	Feet
Fine grained sandy and clayey micaceous shale	20
Bluish compact impure limestone	1½
Total	21½

At the present time the railroad embankment has been reinforced to guard against erosion by high water in the river, covering all exposures below the level of the track.

A short distance farther south, on the north side of a deep ravine, close to the railroad right-of-way, at an elevation of two feet above the track and thirteen feet above extreme low water in the river, is a one foot ledge of yellow Carboniferous limestone in

one layer, underlain by several feet of weathered shale. The river at this point is only a few yards distant from the railroad track and is flowing in a rapid, paved with many bowlders of gray limestone evidently derived from the lower ledge. In the hill south of the ravine Cretaceous shales only are seen reaching thirty feet above the railroad track.

The correlation of the limestone ledges is difficult and is attempted with hesitation, as the outcrop is meager. However, fossils were collected both from the upper ledge and from a pier of the old Keystone mill which evidently was constructed with stone from the lower gray limestone whose outcrop, now concealed, was only fifty feet distant. The fauna and lithology of the limestones are not in close agreement with the limestones near Essex. Lonsdale states that a deep drilling was done in this immediate vicinity and it was claimed a coal seam eight inches thick was found ninety feet below the river. If this record is correct the coal without doubt is the Nodaway coal, and the limestones can be correlated, the lower with the Burlingame and the upper with the Fargo. The Rulo apparently is absent in the Brownville syncline in Iowa.

COMPOSITE SECTION ON RIVER SOUTH OF RED OAK.

		Feet
6.	Shale, light gray, friable, with streaks of orange colored sand	9
5.	Shale, arenaceous, micaceous, light gray, concretions	11 to 27
	Unconformity	
4.	Sandstone, yellow, unconformity, friable, massive, with limonite concretions	0 to 16
3.	Limestone, yellow, one layer	1
2.	Shale, blue	11
1	Limestone, light gray, one layer	1½
	Total	49½

There is much of interest in these outcrops that extend along the river for half a mile. Although now somewhat obscured they show the unconformity between the Carboniferous and Cretaceous as well as one within the Cretaceous.

Four miles north of this locality and two miles north of the city of Red Oak, at the site of the old Clark mill, on East Nishnabotna river, there is exposed above water level a ledge of limestone eleven feet thick overlain by ten feet of dark yellow friable Cretaceous sandstone. The limestone is impure, light gray and yellow in color, unevenly weathered. Some layers are composed of a mass of comminuted fossils and the whole ledge is

heavily Fusulina bearing. This limestone is the Forbes, which is so prominent at Stennett. The visit here was made in December, the river was frozen over, and the weather was extremely cold accompanied by snow squalls which precluded any attempts at fossil collecting. From the Wayne stennett quarry on Pilot creek near Stennett to this outcrop the course of East Nishnabotna river is coincident for five miles with the strike of the Forbes as it dips east on the northwest limb of the Brownville syncline. Two miles north of the Clark mill site outcrop, the Cedar Creek ledge is exposed along the roadside well above the bottom land and less than a mile from the river. This ledge is about twenty feet lower in the general section than the Forbes. In the absence of a topographic map and precise leveling it is estimated the dip on the northwest limb of the Brownville syncline is S. 60 degrees E., at the rate of sixty feet to the mile. It is probable the Forbes is present only in a limited outlier west of the river at Stennett and vicinity. There is no evidence of a fault near Red Oak, the heavy dip being sufficient in the four miles from the Clark mill to the Keystone mill to bring in the City Bluffs at the latter place.

The main limestone ledge at Stennett has been regarded as equivalent to the limestone at Forbes, Missouri. The Missouri Geological Survey, in Volume 13, has correlated the Forbes limestone with and adopted the name Deer Creek of Kansas. However, as it is at least fifty miles from the nearest outcrop of the Deer Creek in Missouri to that in Iowa near Corning, where the Stennett main ledge is exposed in the bed of the East Nodaway river this very wide correlation is subject to much criticism. The Missouri Survey gives the following section for the Deer Creek in that state.

		Feet
5.	Limestone, gray, cherty, thick or thin bedded	13 to 15
4.	Shale, black and slaty in the middle	5
3.	Limestone, gray, fine grained with specks of calcite	2
2.	Shale	7
1.	Limestone, soft, buff, argillaceous	5

This does not correspond with any sequence of strata known in Iowa. Until the connection between these limestones has been traced in the field it would be more judicious to avoid all correlations. The writer has carefully studied the faunal lists given by Girty in the Missouri report referred to and finds the Iowa limestone to be paleontologically allied with the Topeka. There

are many chances of error in exact correlations fifty miles apart in a heavy drift covered region.

Two miles southeast of Clarinda the writer was fortunate to discover an excellent exposure of the cap rock of the Nodaway coal at the site of the old Shambaugh mill, locally known as Pinhook. A drainage canal has diverted the course of the river some distance to the west. The old river bed is silted up, with brush growing in it. The outcrop is not in as good condition as it was at the time of Doctor Calvin's visit when he obtained his section at an old mine drift now completely slumped away. However, the cap rock and roof shale of the coal are well exposed. Doctor Calvin's section is better than any to be obtained at present and will be given:

SECTION AT PINHOOK NEAR CLARINDA.

		Feet	Inches
9.	Yellow weathered shale	4	
8.	Black shale	1	
7.	Yellow shale	1	3
6.	Yellowish impure limestone which at the north end of the exposure is in two layers, the upper 14 and the lower 18 inches in thickness. The lower bed thins and runs out in a few yards to the south. Average thickness	2	
5.	Yellowish shale, present in some parts of the exposure and absent in others		6
4.	Black, slaty shale		6
3.	Grayish, fossiliferous, non-laminated shale which disappears and re-appears in distances of a few yards. Among the fossil species noted are: *Lophophyllum profundum*, plates and spines of Zeacrinus, *Rhombopora lepidodendroides*, *Chonetes granulifer*, *Productus pertenuis*, *Derbya crassa*, represented by numerous small, fragile individuals, *Spiriferina kentuckiensis*, *Ambocoelia planoconvexa*, represented by detached valves but very abundant, *Athyris subtilita*, *Straparollis catilloides*, *Bellerophon percarinatus*, *Bellerophon carbonarius*, and a small pleurotomaria	2	
2.	Coal	1	6
1.	Drab shale down to river	8	

Doctor Calvin's faunal list of the roof shales gives the dominant fossils of this horizon. The lithology of the cap rock is such that it can be readily recognized. It is an impure limestone, subcrystalline, in many places reddish in color, and breaks with a splintery fracture. This cap rock has been correlated with the Howard formation of Kansas, a name derived from a locality near the southern border of that state. It is inconceivable a thin ledge of limestone less than three feet thick should preserve an unbroken continuity for a distance of two hundred and fifty

miles. No such other instance is known in American geology. This cap rock no more deserves the taxonomic rank of a formation than the similar cap rocks over the Elmo and Nyman coals. The writer again would advise that correlations in this geological field be carefully considered, as it is impossible that correct interpretations of its stratigraphic relations can be achieved by only a few days of reconnoisance work. The statement of Doctor F. V. Hayden in Final Report on Nebraska, Page 15, "These Upper Coal Measure rocks seem to be as changeable in their lithogical characters as those of the Tertiary period. What adds to the difficulty, also, is the fact the same species of fossils, with few exceptions, run through all the beds" has much application even today.

Condra and Bengtson's report "The Pennsylvanian Formations of Southeastern Nebraska" is difficult to obtain, and their ledge names and numbers will be given as far as they are exposed in outcrop in the six counties of the two southern tiers of counties in southwestern Iowa:

	Nebraska City.	12.	South Bend.
	Nyman coal.	11.	Louisville.
18.	Tarkio.	10.	Union.
17.	Preston.	9.	Meadow.
16.	Burlingame.	8.	Forbes.
15.	Fargo.	7.	Cedar Creek.
	Nodaway coal.		

The Ashland (13) and Rulo (14) ledges of Nebraska are not definitely known to be present in Iowa.

PALEONTOLOGY.

Collections of fossils have been made at Essex, Coburg, Red Oak, also at Pinhook, and the different coal mine dumps near Clarinda. This continued study without greatly increasing the number of species already known has extended the range of many species, so that it may be stated there is no abrupt change in the fauna throughout the whole section. During the greater part of a season a species may be searched for in vain when by fortuitous accident it can be collected by the dozen at a horizon where hitherto it has not been found. This well illustrates the statement made by Doctor Calvin many years ago that the fauna of the Missouri stage is found gregariously in colonies. There has been much difficulty experienced in the identification of species in the genus Marginifera. Norwood and Pratten in 1855 described three small species of productids of which *Productus*

splendens and *P. wabashensis* were for years afterwards generally identified as *P. longispinus* Sowerby. Meek in the Final Report on Nebraska, following Davidson, referred, though doubtfully, the Nebraska species to *P. longispinus,* at the same time stating that it was identical with *P. wabashensis* N. & P. Stuart Weller in Carboniferous Invertebrates, Bulletin 153, U. S. Geological Survey, gives *P. splendens* as synonym of *P. longispinus* and gives full generic value to *P. wabashensis.* The writer in the past has endeavored to follow Weller in identifications. With the usual imperfect material found it seems impossible to discriminate these two species. Although the extremes can be differentiated it is thought they merge into one another, and the identification of much the greater number of specimens is largely a matter of personal opinion. It would simplify things greatly if all the Marginifera were referred to *M. wabashensis.* The same condition is found with the genus Chonetes where the same species vary so greatly in the number of the cardinal spines, prolongation of the ears, and depth of the mesial sinus as to cause difficulty in coming to a decision whether one is dealing with only a variety or with a good species. There is also difficulty with the gastropods as the greater number are found in shale and in an imperfect condition. *Sphaerodoma primogenia* has been listed as found in these strata. However, White states in Indiana Report for 1883 that this species is without a columnar fold whereas all specimens of Sphaerodoma collected, so far as can be ascertained with rather poor material, have such a fold. Meek in the Final Report on Nebraska refers his species to (*Macrocheilus*) *S. intercalaris.* However, his figure does not show the aperture and he gives no diagnosis. Meek and Worthen in a figure in Illinois Paleontology, Volume 2, show this species without a columnar fold. Most of the specimens can be identified as *S. paludinaeformis,* leaving much material conjectural, though this may be included in *S. intercalaris.* Many small pelecypods are found which can not well be classified, and their identification is fraught with difficulty and is questionable. The writer has been criticised in his identification of *Marginifera muricata* in the Forbes and City Bluffs. In Bulletin 211 U. S. Geological Survey Girty lists *M. muricata* as present in the Lecompton and Deer Creek of Kansas. This species or one closely allied to it is present in the Iowa formations. However, the writer does wish to be dogmatic as to the possible species in the genus Margini-

fera. Stuart Weller's determinations in the monograph on "Mississippian Brachiopoda," Illinois Geological Survey, have been followed in placing Derbya as a synonym of Orthotetes. The identification of *Orestes nodosum* is made with confidence from Girty's excellent descriptions and figures, without type specimens, thus greatly extending the range of this species. Detached stem fragments and plates of crinoids are abundant throughout the whole series of strata. The identification of crinoid species from a single separate plate is extremely hazardous. As Meek states, Erisocrinus and Ceriocrinus can not be distinguished by detached plates. It is unusual that Fusulina can not be found in any limestone ledge. The writer has in great measure been dependent on the "Final Report on Nebraska," Meek and Hayden, for his identification of species as Meek's well known paleontological work in this report was done in the same geological field as the writer's. Where Meek has given descriptions and figures his identification of species is accepted without question. The recent "Fauna of the Wewoka Formation" by Girty has been of great service, although the nomenclature given there has not in all instances been followed. Paleontological nomenclature at present is in a transitory state, and there probably will be many changes in the future.

The faunal expression is somewhat earlier in type than found in equivalent horizons farther to the southwest according to faunal lists published in other states. It is quite possible that in the great trough of the Brownville syncline, life conditions in the Pennsylvanian were such that species continued later than in the more abyssal seas of the southwest.

ESSEX FAUNA—TARKIO.

Fusulina secalica.	Ambocoelia planoconvexa.
Lophophyllum profundum.	Heustedia mormoni.
Ceriocrinus hemisphericus.	Meekella striatocostata.
Rhombopora lepidodendroides.	Productus costatus.
Fistulipora nodulifera.	Orthotetes crassa.
Pugnax uta.	Spiriferina kentuckiensis.
Marginifera wabashensis.	Allorisma terminale.
Chonetes granulifer.	Myalina swallovi.
Chonetes geinitziana.	Pleurotomaria subdecussata.

ESSEX FAUNA—PRESTON.

Fusulina secalica.	Fenestella perelegans.
Lophophyllum profundum.	Orthotetes crassa.
Archaeocidaris dinnini.	Enteletes hemiplicata.
Polypora submarginata.	Seminula argentea.
Fistulipora nodulifera.	Chonetes granulifer.
Rhombopora lepidodendroides.	Productus punctatus.
Septopora biserialis.	Edmondia nebraskensis.

The dominant fauna of the Preston is bryozoa. Besides the species listed several indeterminata were found.

COBURG FAUNA—TARKIO.

RED OAK FAUNA—BURLINGAME.

Fistulipora nodulifera.
Rhombopora lepidodendroides.
Enteleles hemiplicata.
Orthotetes crassa.
Spirifer cameratus.
Chonetes granulifer.
Spirifer cameratus.
Chonetes granulifer.
Bellerophon bellus.
Hydreionocrinus, spines.
Ambocoelia planoconvexa.
Aviculopecten occidentalis.

RED OAK FAUNA—FARGO.

Fusulina secalica.
Lophophyllum profundum.
Archaeocidaris dininni.
Hydreionocrinus mucrospinus.
Polypora submarginata.
Fistulipora nodulifera.
Septopora biserialis.
Rhombopora lepidodendroides.
Chonetes granulifer.
C. verneuiliana.
Ambocoelia planoconvexa.
Seminula argentea.
Spirifer cameratus.
Spiriferina kentuckiensis.
Orthotetes crassa.
Productus nebraskensis.
Productus semireticulatus.
Aviculopecten mccoyi.

PINHOOK FAUNA—NODAWAY COAL CAP ROCK.

Fusulina secalica.
Fistulipora nodulifera.
Rhombopora lepidodendroides.
Polypora submarginata.
Productus semireticulatus.
Productus cora.
Productus pertenuis.
Productus nebraskensis.
Chonetes granulifer.
Marginifera wabashensis.
Chonetes verneuiliana.
Seminula argentea.
Ambocoelia planoconvexa.
Myalina perattenuata.
Myalina swallovi.
Nucula ventricosa.
Edmondia nebraskensis.
Edmondia reflexa.
Bellerophon crassus.
Orestes nodosus.
Naticopsis altonensis.

CLARINDA MINES FAUNA. NODAWAY COAL SHALES.

Lophophyllum profundum.
Lophophyllum distorta.
Ceriocrinus hemisphericus.
Hydreionocrinus mucrospinus.
Rhombopora lepidodendroides.
Seminula argentea.
Ambocoelia planoconvexa.
Hustedia mormoni.
Productus pertenuis.
Productus nebraskensis.
Orthotetes crassa.
Edmondia reflexa.
Nucula ventricosa.
Euomphalus catilloides.
Euphemus carbonarius.
Sphaerodoma brevis.
Spiriferina kentuckiensis.
Chonetes granulifer.
Chonetes verneuiliana.
Chonetes geinitziana.
Marginifera wabashensis.
Trepospira sphaerulata.
Phanerotrema grayvillensis.
Worthenia tabulata.
Bellerophon percarinatus.

SHENANDOAH.